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UNITED STATES DEPARTMENT OF COMMERCE

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United States Patent and Trademark Office

September 28, 2000

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APPLICATION NUMBER: ***60/154,367***
FILING DATE: ***September 17, 1999***

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A/PROV

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(b)(2)

Docket Number	UBC 99-055	Type a plus sign (+) inside this box →	

INVENTOR(s)/APPLICANT(s)			
LAST NAME	FIRST NAME	MIDDLE INITIAL	RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY)
Hodgson	Antony	J.	Vancouver, Canada
Inkpen	Kevin	B.	Vancouver, Canada

~~TITLE OF THE INVENTION (280 characters max)~~

Object Tracker Minimally Constrained by Normal Forces

CORRESPONDENCE ADDRESS

Maureen A. Beattie
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Province	British Columbia	Postal Code	V6T 1Z3	COUNTRY	Canada

ENCLOSED APPLICATION PARTS (check all that apply)

X	Specification/Figures	*Number of Pages*	5	X	Small Entity Statements	
	Drawing(s)	*Number of Sheets*		☐	Other (specify)	Conferene paper to be presented Sep. 19/99 (8 pgs.)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)

X	A check or money order is enclosed to cover the filing fees	FILING FEE AMOUNT(S)	$75.00
☐	The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number:		

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

X No

☐ Yes, the name of the U.S. government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE Maureen A. Beattie Date Sep. 16/99

TYPED OR PRINT NAME Maureen A. Beattie REGISTRATION NO. (if appropriate)

☐ Additional inventors are being named on separately numbered sheets attached hereto.

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Burden Hour Statement: This form is estimated to take .2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS. SENT TO: Box Provisional Application, Assistant Commissioner of Patents, Washington, DC 20231.

99-055

Applicant or Patentee: **Antony John Hodgson, and Kevin Bryant Inkpen**
Serial or Patent No.:
Filed or Issued:
For: **Object Tracker Minimally Constrained by Normal Forces**

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9 (f) and 1.27 (D)) - NONPROFIT ORGANIZATION

I hereby declare that I am an official empowered to act on behalf of the nonprofit organization identified below

NAME OF ORGANIZATION **The University of British Columbia**
ADDRESS OF ORGANIZATION **2075 Wesbrook Mall Vancouver, British Columbia, Canada V6T 1Z1**

TYPE OF ORGANIZATION [X] University or other institute of higher education

I hereby declare that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9 (e) for purposes of paying reduced fees under section 41 (a) and (b) of Title 35, United States Code with regard to the invention entitled: **Object Tracker Minimally Constrained by Normal Forces** inventors **Antony John Hodgson and Kevin Bryant Inkpen.**

[X] the specification filed herewith
[ ] application serial no. , filed

I hereby declare that the rights under contract or law have been conveyed to and remain with the nonprofit organization with regard to the above identified invention.

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28 (b)).

I hereby declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both under section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which the verified statement is directed.

NAME OF PERSON SIGNING ____________________

Title of Person signing Angus Livingstone, Managing Director, University - Industry Liaison Office

Address of Person Signing 2194 HEALTH SCIENCES MALL, RM. 331, IRC BLDG. UBC, UILO, VANCOUVER. B.C. V6T 1Z3 CANADA.

Signature [signature] Date September 16 1999.

09/401459

Applicant or Patentee: **Antony John Hodgson, and Kevin Bryant Inkpen,**
Serial or Patent No.:
Filed or Issued:
For: **Object Tracker Minimally Constrained by Normal Forces**

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9 (f) and 1.27 (b)) - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9 (c) for purposes of paying reduced fees under section 41 (a) and (b) of Title 35, United States Code to the Patent and Trademark Office with regard to the invention entitled:

Object Tracker Minimally Constrained by Normal Forces

described in

[X] the specification filed herewith
[ ] Application Serial No.
[ ] Patent no. issued

I have not assigned, granted, conveyed or licensed and am under not obligation, under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9 (c) if that person made an invention or to any concern which would not qualify as a small business concern under 37 CFR 1.9 (d) or a nonprofit organization under 37 CFR 1.9 (e).

Each person, concern or organization to which I have assigned, granted, conveyed or licensed or am under an obligation under contract or law to assign, grant, convey or license any right in the invention is listed below:

[ ] no such person , concern or organization.
[X] persons, concerns or organizations listed below

FULL NAME **The University of British Columbia**

ADDRESS **2075 Wesbrook Mall, Vancouver, British Columbia, Canada V6T 1Z1**

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28 (b)). I hereby declare that all the statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that wilful false statements and the like so made are punishable by fine or

imprisonment, or both under section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which the verified statement is directed.

Antony John Hodgson
NAME OF INVENTOR

Signature of Inventor 9/15/99
Date

Kevin Bryant Inkpen
NAME OF INVENTOR

Signature of Inventor 9/15/99
Date

THE UNIVERSITY OF BRITISH COLUMBIA

September 16, 1999

Hon. Commissioner of Patents and Trademarks,
U.S. Patent and Trademark Office,
U.S. Department of Commerce,
Box Provisional Application,
Assistant Commissioner of Patents,
WASHINGTON, DC 20231,
U.S.A.

Dear Sir:

Re: Provisional Application for "Object Tracker Minimally constrained by Normal Forces" UBC file 98-113

Enclosed please find the necessary documents for filing a Provisional Application for the above-identified application on behalf of The University of British Columbia. Also enclosed is a cheque in the amount of $75.00 US being payment for the filing fee.

Thank you,

Sincerely,

Maureen A. Beattie

Maureen A. Beattie,
Patent Administrator.

/mb
Encl.

U·I·L·O

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Commissioner of Patents and Trademarks
Correspondence and Mail Division
Patents and Trademarks Office
Crystal Plaza
Building 2, Room 1A01
Arlington, Virginia
USA 22202

Enclosures:

1. Provisional application for patent cover sheet
2. Fee of $75.00 US
3. Declaration of nonprofit organization
4. Declaration Claiming Small Entity Status – Independent Inventor
5. Specifications/Figures (5 pages)
6. Conference paper (8 pages)

Provisional Patent Application for a Device Constrained Against an Apposed Body Through Normal Forces

Antony J. Hodgson and Kevin B. Inkpen

September 15, 1999

Motivation:

There are a variety of situations in surgery, biomechanical research, gait analysis and ergonomic analysis in which one would like to know the position of a bony structure during motion or manipulation. Approaches to measuring body motion can be classified are either invasive (typically using bone pins or screws placed through a skin incision) or non-invasive (attaching external markers to the skin or simply making a video record of the motion).

Non-invasive markers are clearly attractive from the patient's or subject's perspective, but they suffer from comparatively low accuracy since they are not mounted directly to the bony structure of interest. In particular, skin typically moves easily over bone during motion, which results in discrepancies between the marker position and the position of the bony structure which is presumed to be moving together with the marker. In some cases, these discrepancies can be on the order of centimetres.

Invasive markers are rigidly attached to the underlying bone and so can yield more accurate measurements at the cost of increased pain to the subject and the need for wound care.

There is, therefore, clearly a need for a non-invasive marker that can sustain a fixed relation to the underlying bone while being insensitive to skin motion artifacts. We have developed such markers for the pelvis and ankle, but the underlying principles could be used to design markers for scapular tracking, mounting stereotactic frames to the skull, designing remountable clamps for the distal femur, and a variety of other applications.

Design Concept

Our approach relies on the recognition that one object has six degrees of freedom relative to another when free to move, and zero degrees of freedom when locked together. The difficulties with conventional non-invasive markers arise because they are comparatively free to move in the plane tangent to the skin surface. In contrast, skin which overlies bone is relatively incompressible in the direction normal to the bone, so motion in this normal direction is essentially zero. By creating a larger structure (the "tracker") which contacts the skin overlying a rigid bony object in six locations across interfaces which consist of substantially point contacts (by substantially point contacts, we mean that any individual contact patch is insufficiently large to resist moments which might reasonably be applied to the two bodies in contact and must therefore be paired with another contact patch at some distance from the first), and by applying one or more seating forces (forces which are comparatively insensitive to small motions of the body upon which they act; e.g., gravity, electromagnetic or spring forces) oriented to ensure compressive forces at each contact point, we can constrain the tracker to follow the underlying

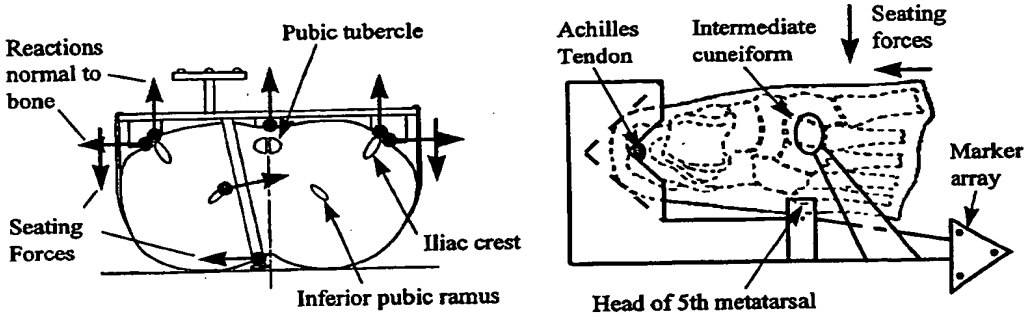
bony structure. Furthermore, if we do not adjust the relative positions of the tracker's contact surfaces, we should be able to release the seating forces, remove the tracker, and replace it again with high repeatability. This capability would be particularly useful when the tracker is required on two different occasions, as is often the case in stereotactic procedures where the halo is mounted for a computed tomographic scan and left in place until the surgery for fear of replacing it in a different orientation.

Typical means of achieving point contact depend on the local radius of curvature and orientation of surface features of the object to which the tracker is to be mounted. If the object has low curvature radii, it is often beneficial to design the tracker interfaces with planar or high curvature radius surfaces (see example below). Conversely, if the object is substantially flat in the region of a desired contact point, the tracker should be designed with a small radius of curvature. Finally, if the object has different radii of curvature in different directions (e.g., a cylinder has a small radius perpendicular to its axis and an infinite radius along its axis), we can achieve a substantially point contact by creating a cylinder-like feature on the tracker and orienting its axis so that it is substantially perpendicular to that of the object (again, see hip tracker example below).

Hip and Foot Tracker Design

The following section is an extract from a paper we have recently written describing the implementation of this design concept in the form of trackers for the pelvis and foot for use in computer-assisted knee surgery:

In order to minimize artifacts due to relative motion caused by skin sliding over bone, we designed our hip and foot trackers to constrain all six degrees of freedom by applying six reaction forces only normal to the bone (see Figure 1; note that proximal-distal components of forces are not shown). The trackers are fully adjustable to accommodate different patients and seating forces are applied by straps. Each tracker has an optical marker array rigidly attached.



(a) Transverse section (looking proximally) through pelvis (b) View looking distally on right foot.

Fig. 1. (a) Hip tracker and (b) foot tracker devices

Photographs of Hip Tracker Design

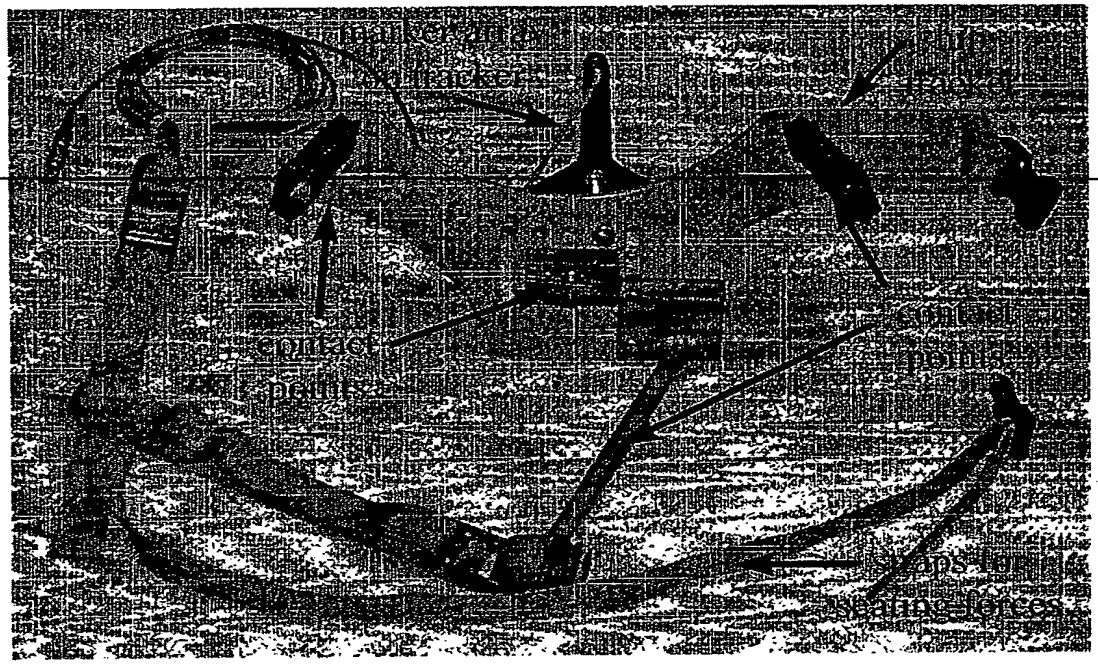


Figure 1. Detail of hip tracker. The central blue block is a planar surface which rests on the pubic tubercle at a single contact patch. The extension rod crosses the pubic ramus at an angle and so also creates a single contact patch. Each of the remaining two blue blocks have two planar surfaces which rest on the pelvic iliac spines and so create two contact patches each.

Figure 2. A photograph of the device in use on a skeletal model. Note that the distribution of normal forces is designed to resist any force or torque applied to the tracker up to a finite limit determined by the preload on the straps.

Claims:

1. A device which consists of six rounded or planar surfaces ("interface elements") which can be placed tangent to six corresponding surfaces on a second body, and one or more force-generating means (such as springs, weights or electromagnetic fields) aligned so as to ensure positive contact at all six interface elements. The interface elements should be oriented such that the resulting normal forces substantially constrain the device relative to the second body (by having, for example, sufficient relative moment arms to resist applied torques about arbitrary axes). Each interface element should generate a contact patch that is essentially point-like in nature; by point-like, we mean that the contact patch alone is insufficiently large to prevent relative movement when typical moments are applied to the two bodies in contact.
2. A device as described in (1) which allows for adjustability in the position and orientation of one or more of the interface elements, so as to allow for optimal fitting to different second bodies.
3. A device as described in (1) or (2) to which is mounted some means for detecting its position in space (e.g., an optoelectronic or magnetic tracker) for the purpose of inferring the position of the apposed second body.
4. A device as described in (1), (2) or (3) in which the second body consists of a rigid structure overlaid with a comparatively thin layer of a deformable substance which is comparatively free to move in directions tangent to the rigid structure (e.g., a bony structure overlaid with a comparatively thin layer of soft tissue and skin).
5. A device as described in (4), customized for the pelvis (as outlined in our paper).
6. A device as described in (4), customized for the foot (as outlined in our paper).
7. A device as described in (1), (2), (3) or (4) with fewer than six interface elements so as to constrain selected degrees of freedom between the device and the second body.